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ESTAR Experience with RFI at L-band and Implications for Future Passive Microwave Remote Sensing from Space

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Abstract-Although the spectral window at 1.413 GHz (L-band) is protected for passive use, radiometers for remote sensing commonly encounter problems with RFI. Experience with the synthetic aperture radiometer, ESTAR, suggests that airports are one source of this RFI. The existence of RFI at L-band could be a problem for future remote sensing from space.

I. INTRODUCTION

The spectral window at 1.413 GHz (L-band), set aside for passive use only, is critical for remote sensing from space [1]. It is the largest spectral window available at the long wavelength end of the microwave spectrum, and long wavelengths are needed for monitoring parameters such as soil moisture and sea surface salinity. The importance of soil moisture and sea surface salinity for understanding the global hydrologic cycle and ocean circulation, is reflected in the new sensors and remote sensing missions that recently have been proposed to make measurements at L-band from space (e.g. Aquarius [2], Hydros [3] and SMOS [4,5]).

Although the window at 1.413 GHz is protected for passive use, RFI is a common problem. For example, during the Southern Great Plains experiments [6,7], the ESTAR radiometer [5,8] experienced RFI significant enough to warrant changes in flight lines. Noise levels frequently were sufficient to saturate the total power channel. RFI has been a sufficiently common problem for ESTAR, that the first step in processing data is to screen for RFI (a filter is used in data processing to detect rapid changes in brightness temperature).

RFI is a serious concern for future passive remote sensing missions in space. This is especially true for synthetic aperture radiometers because they employ small antennas with a wide field-of-view. The measurement of salinity is particularly vulnerable to RFI because of the extreme radiometric sensitivity (better than 0.2 K) needed to detect small changes in salinity in the open ocean [2]. Studies done during the design of the synthetic aperture radiometer, HYDROSTAR [5], suggest that spurious radiation from air traffic control radar can not be ignored by future L-band sensors in space. (See Section III below.)

II. EXPERIENCE WITH ESTAR

ESTAR is a hybrid synthetic-and-real aperture radiometer. It employs long, "stick" antennas to achieve resolution along track and uses aperture synthesis to achieve resolution across track [8,9]. The use of aperture synthesis across track permits substantial thinning of the array, reducing the number of sticks needed. Thinning could also be done in the along track dimension to further reduce the real aperture. This is being done in Europe for the SMOS mission to measure soil moisture and ocean salinity [5]. Aperture synthesis works well with antennas that have broad beams in the dimension where resolution is to be synthesized. However, broad antennas are particularly sensitive to RFI since radiation is received from a wide field-of-view. In the case of ESTAR, the field-of-view is restricted (about ± 8 degrees) in the along track dimension by the antenna aperture. However, in the across track dimension incoming signals from all angles are received.

Fig. 1 is an ESTAR image made in 1997 in the vicinity of Richmond, VA. The image has been superimposed on a map of land-water boundaries to help identify features. At the far right is the Chesapeake Bay, and the York and James Rivers are visible in the image. This image is the composite of several east-west lines flown at 25 kft with ESTAR aboard the Orion P-3B aircraft based at NASA's Wallops Flight Facility. In this image, the RFI filtering normally done in software was not performed in order to illustrate the problem. The small, vertical, white dashes are strong signals associated with RFI. To get an idea of the temporal structure of these signals, the raw data from the zero spacing channel (total power radiometer) is shown in Fig. 2. The data shown is the uncalibrated output from a noise injection radiometer. This data was collected at about 77 WLong at the location of the arrow in Fig. 1. The periodic spikes are RFI. The undulating signal on which they ride is the slow variation in total power one normally associates with changes in surface features (e.g. soil moisture and vegetation canopy) at L-band. The period (10 s) is reasonable for air traffic control radar (e.g. with a rotation rate of about 5 rpm).

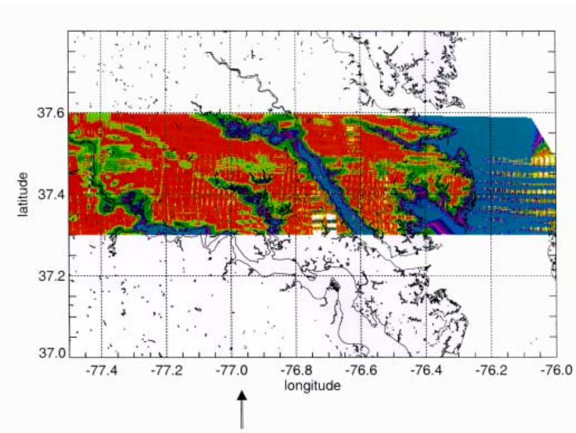

Fig. 1. ESTAR image showing the effects of RFI in the vicinity of Richmond, VA The small vertical stripes are artifacts in the image due to large RFI.